Information Registration as a Physical Accumulation Mechanism

A Cross-Scale Model from Quantum Measurement to Biological Memory

Daniel Jacob Read IV
ĀRU Intelligence Inc.

December 2025

Abstract

A persistent gap exists between theories of measurement, decoherence, memory, and macroscopic stability. While modern physics describes how information is extracted, recorded, and dissipated, it lacks a unifying account of how repeated information registration produces durable structure across scales. This paper proposes that physical accumulation arises not from conscious observation, but from the persistent registration of state information into physical media.

Accumulation is formalized as a time-integrated constraint on state-space evolution, demonstrating how repeated registration suppresses variance, biases trajectories, and stabilizes structure. The framework applies uniformly from quantum measurement and environmental decoherence to biological memory formation and artificial systems. Memory is treated as a physical process—defined by persistent state modification—rather than a mental phenomenon. Testable predictions are provided.

1 Introduction

The relationship between measurement, information, and physical persistence remains conceptually fragmented across modern science. Quantum mechanics, thermodynamics, neuroscience, and computation each address aspects of information processing, yet no unified framework explains why repeated interaction with informational records produces durable structure rather than transient effects.

In quantum systems, measurement suppresses interference. In biological systems, repeated signaling strengthens synaptic pathways. In artificial systems, persistent state prevents catastrophic forgetting. These phenomena are typically treated as domain-specific, despite sharing a common operational structure.

This paper proposes a unifying principle:

> *Physical accumulation occurs when information about a system's state is persistently registered into physical structure.*

No role is assigned to consciousness, belief, or subjective observation. Measurement is defined strictly as physical interaction that irreversibly embeds state information into a recording medium.

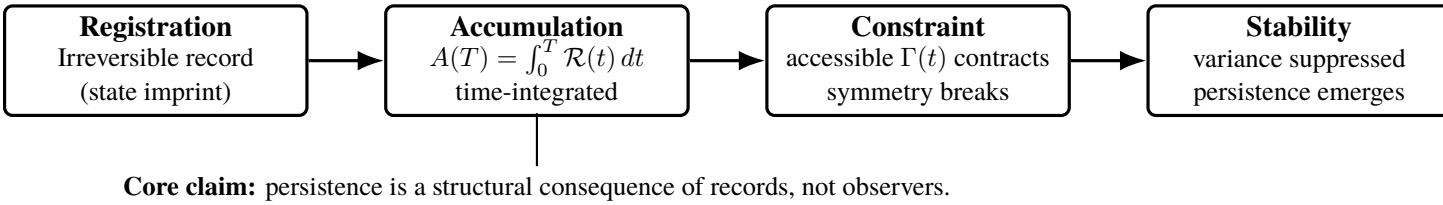

Figure 1: **Mechanism overview.** Registration produces accumulation; accumulation produces constraint; constraint produces stability.

2 Measurement as Information Registration

In standard quantum mechanics, the transition from interference to localization occurs when which-path information becomes available. Crucially, this transition does not require a human observer. Any interaction that entangles a system with external degrees of freedom capable of retaining state information suffices.

We therefore define measurement as:

> **Measurement:** Any physical interaction that irreversibly registers information about a system's state into another physical system.

This definition removes ambiguities surrounding observer dependence. What matters is not observation, but irreversible record formation.

3 Information Registration and Constraint Formation

Once state information is registered, future system evolution is constrained. The system's accessible state-space is reduced, and previously symmetric trajectories become biased.

Let $S(t)$ denote the system state and $R(t)$ a record-bearing subsystem. When an interaction produces the mapping

$$S(t_0) \to \big(S(t_1), R(t_1)\big),$$

the system can no longer evolve independently of the constraints encoded in $R(t_1)$.

Constraint formation is therefore a direct physical consequence of information embedding, not awareness or interpretation.

4 Accumulation Through Repeated Registration

A single registration event alters state probabilities. Repeated registration produces accumulation.

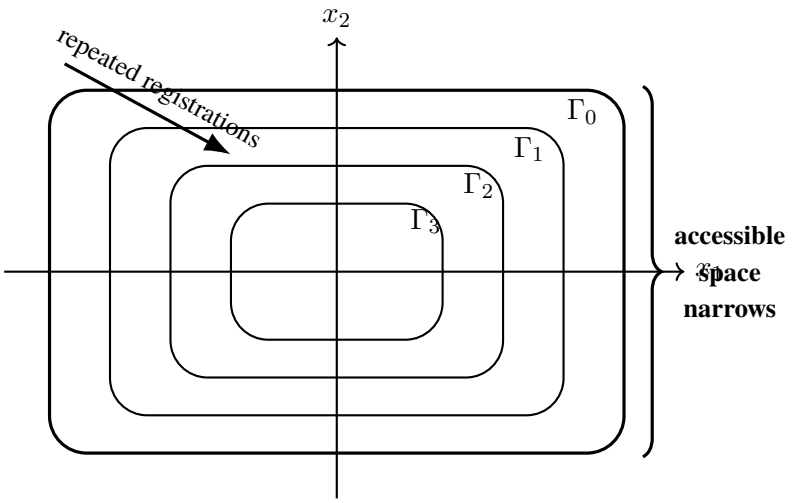

Figure 2: **Constraint formation as contraction.** Each irreversible record eliminates inconsistent futures, narrowing effective accessibility.

Define an accumulation functional:

$$A(T) = \int_0^T \mathcal{R}(t)\, dt,$$

where $\mathcal{R}(t)$ is the *rate of irreversible information registration* (per unit time) into physical structure.

As $A(T)$ increases, the accessible state-space contracts. In minimal form, this produces monotonic stabilization:

- Variance in accessible states decreases,
- Trajectories become increasingly constrained,
- Persistence emerges as a structural property.

A falsifiable phenomenology is variance suppression as a function of accumulated registration:

$$\frac{d\sigma^2}{dA(T)} = -\kappa\sigma^2, \qquad \kappa > 0 \quad \Rightarrow \quad \sigma^2(A(T)) = \sigma_0^2 e^{-\kappa A(T)}.$$

5 Memory as a Physical Process

We define memory physically as:

> **Memory:** A persistent modification of a system's state-space resulting from accumulated information registration.

This definition applies across domains:

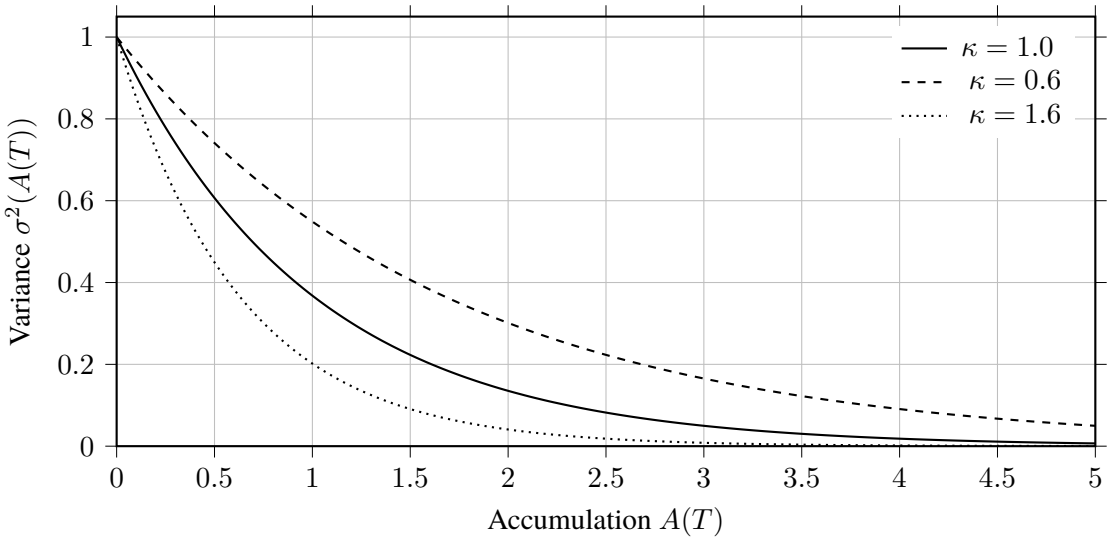

Figure 3: **Variance suppression vs. accumulation.** Different substrates shift κ, but the core prediction is monotonic stabilization with increasing $A(T)$.

- **Quantum:** environmental records suppress coherence,
- **Classical:** structural traces bias motion,
- **Biological:** synaptic modification stabilizes behavior,
- **Computational:** stored state prevents forgetting.

Memory is therefore not fundamentally mental. It is a physical consequence of constraint accumulation.

6 Cross-Scale Unification

The same accumulation mechanism operates at all scales, differing only in medium and timescale. Quantum environments, neural tissue, and computational memory differ materially, yet obey identical accumulation dynamics.

Existing theories describe local behavior. This framework identifies what those behaviors have in common: persistent information registration as the driver of structural stability.

7 Relation to Existing Theory

This model is consistent with decoherence theory, Landauer's principle, neural plasticity, and information-theoretic thermodynamics. Its contribution is not contradiction, but unification: isolating the shared mechanism underlying stability across domains.

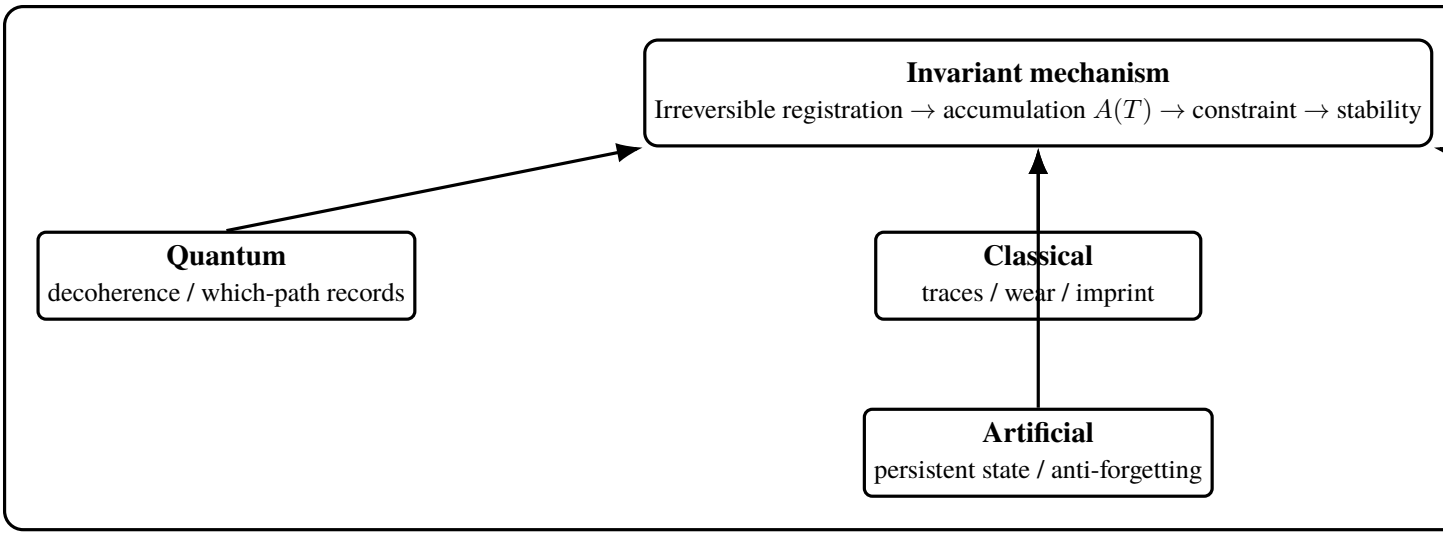

Figure 4: **Cross-scale unification.** Different media implement different records, but the mechanism remains the same.

8 Testable Predictions

This framework predicts:

- Systems exposed to sustained, low-energy information registration stabilize faster than systems subjected to high-energy but transient interaction.
- Artificial systems lacking persistent state exhibit accelerated forgetting regardless of computational scale.
- Biological and artificial memory degradation correlates with disruption of physical record persistence, not signal intensity alone.
- Stabilization metrics should scale monotonically with $A(T)$, enabling direct falsification of specific functional forms (including exponential decay).

9 Conclusion

Physical structure persists because information persists. Measurement, memory, habit, and stability arise from the same mechanism: accumulated constraint imposed by repeated information registration.

Accumulation is not an emergent mystery layered atop physical law. It is an inevitable consequence of allowing information about a system's state to remain embedded in physical structure over time. Where records persist, trajectories narrow. Where trajectories narrow, stability appears.

This is not a claim about belief or interpretation. It is a claim about what physical systems do when information is allowed to stay.

Copyright Notice

© 2025 Daniel Jacob Read IV

All Rights Reserved

This work is an original theoretical contribution. The concepts, definitions, formulations, and structural framework presented herein are the intellectual property of the author. No part of this document may be reproduced, distributed, transmitted, or adapted in any form or by any means—electronic, mechanical, or otherwise—without prior written permission of the copyright holder, except for brief scholarly quotation with proper attribution.

This document is released as an archival scientific preprint. It is intended for critical examination, theoretical discussion, and experimental evaluation. The author makes no appeal to belief, authority, or interpretation beyond the physical mechanisms described.

Author: Daniel Jacob Read IV
Affiliation: ĀRU Intelligence Inc.
Document: *Information Registration as a Physical Accumulation Mechanism*
Edition: Archive / Preprint Edition
Date: December 2025